

## **Safe Electronic Pyro Trigger**

### **Field of the Invention**

[0001] The present invention relates to electronic pyro triggers, and in particular, to a failsafe electronic pyro trigger.

### **Background of the Invention**

[0002] Explosive devices including blast caps are routinely pyro tested in blast cells by test engineers or technicians. When pyro testing, people need a fail safe electronic trigger to protect them while working in a blast cell. When a faulty blast cap is encountered during testing, it is crucial to know that a blasting trigger will not try to fire the cap after a count down is over, or halted by an abort command.

### **Summary of the Invention**

[0003] An electronic trigger for pyro testing has a mechanical relay that is normally open. The relay is fired by electronic logic that times out two seconds after attempting to close the relay to trigger a device, such as a device coupled to explosive material. This results in the relay returning to its normally open state. By virtue of the mechanical relay being in a normally open state, no current may pass through the relay after the logic times out.

[0004] In one embodiment, the electronic logic is a microprocessor. The microprocessor has an enable arm switch and an abort switch as inputs. The microprocessor operates software that drives a solid state relay linked to a mechanical relay that fires a blasting cap device. Another output drives a transistor that controls a field that drives the mechanical relay. A four bit output drives a display for showing a count down following user activation of the enable arm switch. The countdown is stopped upon activation of the abort switch, also preventing activation of the solid state relay and the field in the mechanical relay.

### **Brief Description of the Drawings**

- FIG. 1 is a block diagram of a fail safe electronic pyro trigger according to an embodiment of the invention.
- FIG. 2 is a more detailed block diagram of the fail safe electronic pyro trigger according to an embodiment of the invention.
- FIG. 3 is a block diagram of top view of a fire box incorporating the fail safe electronic pyro trigger according to an embodiment of the invention.
- FIG. 4 is a flow chart of functions performed by the fail safe electronic pyro trigger according to an embodiment of the invention.

### **Detailed Description of the Invention**

[0005] In the following description, reference is made to the accompanying drawings that form a part hereof, and in which is shown by way of illustration specific embodiments in which the invention may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention, and it is to be understood that other embodiments may be utilized and that structural, logical and electrical changes may be made without departing from the scope of the present invention. The following description is, therefore, not to be taken in a limited sense, and the scope of the present invention is defined by the appended claims.

[0006] The functions or algorithms described herein are implemented in software or a combination of software and human implemented procedures in one embodiment. The software comprises computer executable instructions stored on computer readable media such as memory or other type of storage devices. The term “computer readable media” is also used to represent carrier waves on which the software is transmitted. Further, such functions correspond to modules, which are software, hardware, firmware or any combination thereof. Multiple functions are performed in one or more modules as desired, and the embodiments described are merely examples. The software is executed on a digital signal processor, ASIC,

microprocessor, or other type of processor operating on a computer system, such as a personal computer, server or other computer system.

**[0007]** A fail safe electronic trigger system is shown generally at 100 in FIG. 1. In one embodiment, system 100 has a user input 110 having a first enable switch 112, a second enable switch 114 and an abort switch 116 coupled to a controller 120. The controller may be a microprocessor or any other type of device capable of executing logic to provide one or more output signals in response to multiple inputs. In one embodiment, the outputs are used to provide a status of the controller, including a visible countdown on a display 125 for activation of a blasting cap represented as output 130. An output 132 to display 125 is a four bit output in one embodiment to drive a single character 7 segment light emitting diode (LED) display. Many other types of outputs and displays may be used.

**[0008]** First enable switch 112 is an enable arm switch that is used to initialize or arm the controller 120, and the second enable switch 114 is an enable count switch that is used to start a countdown by the controller 120. Numerous other types of switches may also be used.

**[0009]** The controller also drives a relay 135 that is linked to a mechanical blasting relay 140 that fires the blasting cap at 130. Relay 135 is a solid state relay in one embodiment. Blasting relay 140 is normally open. Another output is coupled to a current amplifier 142 that drives a relay 145 that controls a field that drives the blasting relay 140. Output 132 drives the display 125 for showing a count down following user activation of the enable count switch 114. The countdown is stopped upon activation of the abort switch 116, also preventing activation of the solid state 135 and blasting 140 relays. A predetermined time after the countdown ends, activation of the solid state 135 and blasting 140 relays is also prevented.

**[0010]** Further detail of the system 100 is shown in FIG. 2. Display 125 contains both an LED character 210 and a fire lock out lamp 215, which is on when the blasting relay 140 is prevented from firing the blasting cap. Solid state relay 135 contains an element or circuitry logically represented as a coil 220 coupled to the controller 120, and a switch 225 activated by the circuitry 220. Switch 225 is

coupled to a switch 230 in blasting relay 140 that is directly coupled to output 130. Blasting relay 140 also contains a field generator such as an inductor or coil 235 for producing a field to activate or enable switch 230 under control of relay 145 containing inductor 240 and switch 245.

**[0011]** FIG. 3 shows a top view of a container or fire box 310 for the system 100. The fire box 310 contains the LED character 210, the fire lock out lamp 215, and switches 112, 114, and 116. It also contains a safety breaker input 315 and blasting cap inputs 320 and 325 which are used to couple the fire box 310 to blasting caps or other explosive or pyrotechnic devices that may be electrically activated. It may also be used for firing model rockets or other recreational devices. In further embodiments, the inputs 320 and 325 may be modified to activate explosives in a different manner, such as magnetically or hydraulically or in any other manner desired.

**[0012]** FIG. 4 is a flowchart showing functions performed by the controller. In one embodiment, the controller is a microprocessor running Parallax, Inc. Basic Stamp<sup>TM</sup> software. Other types of controller and software may be used as is apparent to those of skill in the art.

**[0013]** Power to the fire box 310 is provided at 410. The controller enters into a safe mode 415 by opening relay 145, and ensuring that relay 135 is open. The display is initialized to display that the power is on by displaying a character, such as an "A" for a predetermined amount of time, such as 0.7 seconds, then displaying blank, followed by an "A" again, followed by "0". Any characters may be used. A loop is performed, with the display blinking "0", waiting for the enable switch 112 to be actuated at 420. The display is then set to "E", blanked, set to "A", blanked again, and then set to "F", which blinks in a loop waiting for the enable count switch 114 to be actuated at 425. When the enable count switch 114 is actuated, the display displays an "E" and a "C" for predetermined times, with predetermined delays between, and then counts down from "9" to "0" one second at a time.

**[0014]** At count "0", relay 145 is closed to provide a field to relay 140, one second is waited, and the relay 135 is turned on, enabling current to flow to the blast

cap through relay 140. The display is also set to “B” to indicate blast. A predetermined time is then waited, 3 seconds in one embodiment, and the controller shuts down the field through relay 145 at 440 and shuts down or removes the current at 445. It then enters the safe mode loop at 415. At any time prior to blasting, the abort switch may be actuated at 450, resulting in immediate shut down of the field at 440 and current at 445. The order of these shut downs may be varied in further embodiments. In one embodiment, the blasting cap is fired and explodes while the relay 135 is turned on and current is flowing to the blast cap.

**[0015]** A double safety is provided by the controller shutting down the field of the blasting relay, and shutting down the blast current applied to the blasting cap through the blasting relay. In further embodiments, the controller may be divided into two or more logical components, each coupled to separate relays to accomplish the functions. Other types of relays that require two inputs to trigger may be used to provide the double safety mechanism. One safety mechanism involves providing a continuous signal that allows operation of the blasting relay. In one embodiment, this is the relay that provides current to the coil 235 to create a field and close the switch. A further safety mechanism is the relay 135 that must be activated to provide current through the blasting relay 140 to the blasting cap at output 130. In further embodiments, other types of safety mechanisms are used to enable a switch, and to provide blasting current to the enabled switch. In yet a further embodiment, a short in the blasting cap current loop is detected, causing the controller to shift into the fail safe mode until the firing sequence is restarted. This detection is performed with a circuit breaker, such as a five ampere circuit breaker in one embodiment.